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CORROSION OF REINFORCEMENT STEEL IN POROUS CONCRETE

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CORROSION OF REINFORCEMENT STEEL IN POROUS CONCRETE

-USSR-

[Following is the translation of an article by P. Melenevs'ka in the Ukrainian-language publication Budivel'ni Materialy i Konstruktsii (Building Materials and Structures), Vol IV, No 4, Kiev, 1962, pages 13-15.]

Porous concrete, because of its low specific weight and good heat insulating properties, is being used ever more widely in house and building walls. However, due to tis increased porosity and permeability with respect to air, the steel reinforcement in porous concrete interacts with aggressive media and undergoes severe corrosion. In addition, the concrete itself is aggressive with respect to the steel; the reaction of its hydrogen peroxide with the quicklime produces calcium chloride and diatomic oxygen: $H_2O_2 + CaOCl_2 = CaCl_2 + O_2 + H_2O$.

Because of this, it is necessary to protect the steel reinforcement in the concrete with anticorrosive coatings.

The structure protection laboratory of the Concrete Structures Scientific Research Institute of the Building and Architecture Academy Ukrainian SSR carried out studies of unprotected steel reinforcements in sample blocks 15 X 5 X 5 cm in size. This was accompanied by a study of reinforcement protection in the concrete. The porous concrete was prepared (in accordance with the latest specifications of the Building Administration of the Dnepropetrovsk Sovnarkhoz) as follows: 1 : 0.5 (cement : granulated slag) by weight. The gas-producing agents were hydrogen peroxide and quicklime. The laboratory studies established that the most effective peroxide-quicklime ratio is 1 ; 1.5.

5% of the gas-producing agent (by weight) with respect to the cement was then added. The water-cement ratio was 0.45%.

Steel rods 10 mm in diameter were used as reinforcement. Sample blocks were prepared containing unprotected rods and rods covered with a protective coating. The steel rods to be protected were phosphated, neutralized, and covered with lacquer coatings: Kuzbas lacquer, No 177 bitumen butyrate lacquer, mixture of Kuzbas lacquer with pentachlorvinyl (1 : 1) by weight, and ethylene lacquer. In addition, unphosphated rods were also coated with these lacquers.

Porous Concrete Characteristics

Compression strength after 28 days, kg/cm^2	Bulk weight, g/cm^3	Specific weight, g/cm^3	Porosity, %	Density, %	Water absorptivity, %	Coefficient of air permeability, $1 \cdot 10^{3}$ g/m·hour·mm	pH of water extract
75	1.1	2.22	50.0	50.0	23.0	220	12.4

The porous concrete samples were subjected to thermohumidity processing in a vapor chamber under the following conditions (in hours):

Temperature increase to 85-90°............. 4

Aeration at temperature of 85-90°.......... 8

Cooling to 30-40°......................... 6-8

Following vapor treatment, the porous concrete samples were aerated by means of a blower and subjected to the action of aggressive media: hydrochloric acid vapor and sulfurous anhydride.

The concentration of HCl varied from 0.1 to 10 mg/l over the period of a month; the humidity of the medium changed accordingly from 70 to 100%. The concentration of sulfurous anhydride varied from 100 to 500 mg/l with a 100% humidity of the medium.

The concentration of the indicated gas media exceeded by 100-10000 times the concentration allowed in industrially-produced reinforced porous concrete.

Following treatment in the indicated aggressive media, the samples were broken up after 3 months, 6 months, and 1 year, and the steel reinforcement rods removed.

Bonding of Reinforcement Rods to
Porous Concrete, kg/cm²

Stage of Concrete Processing	Unprotected reinforcement	Protected Reinforcement							
		Phosphate + Kuzbas lacquer	Kuzbas lacquer over unphosphated metal	Phosphate + No 177 bitumen lacquer	No 177 bitumen lacquer (without phosphation)	Phosphate + Kuzbas lacquer with pentachlorvinyl (1 : 1) by weight	Kuzbas lacquer with pentachlorvinyl over metal (without phosphation)	Phosphate + ethylene lacquer	Ethylene lacquer over metal (without phosphation)
After vapor treatment	12.7	15.6	14.8	12.2	7.86	15.3	14.8	12.3	8.9
After 28 days of natural hardening	16.3	17.7	15.1	15.4	12.0	19.5	18.6	14.3	9.81

It was found that the unprotected rods in all media underwent severe corrosion even after 3 months. The degree of corrosion increased with time.

Coating with Kuzbas lacquer and bitumen butyrate No 177 without preliminary phosphation yielded unsatisfactory results. Good results were obtained with phosphation of the steel rods followed by coating with Kuzbas lacquer. The samples so treated indicated no corrosion even after 6 months in an aggressive medium.

Along with the study of steel corrosion in porous concrete, tests were made on the strength of bonding of the concrete to the steel rods. It turned out that the rods phosphated and coated with Kuzbas lacquer were bonded to the concrete more strongly than the unprotected rods.

The use of other lacquers over a phosphated surface (No 177 bitumen butyrate and ethylene lacquers) resulted in weaker bonding.

The results of the tests are shown in the above table.

On the basis of our studies of anti-corrosion protection of steel reinforcement in porous concrete, it is possible to recommend phosphation, neutralization, and Kuzbas lacquer coating.

[Captions:] Fig 1. Character of corrosion of unprotected reinforcement after a 6-month exposure to the air.

Fig 2. Cracks in concrete due to the expanded volume of corrosion products in a sulfurous anhydride medium.

Fig 3. Reinforcing rod following exposure of concrete sample to the air for 6 months.

Fig 4. Reinforcing rod following exposure of samples to hydrochloric acid vapor for 6 months. a -- protected with anti-corrosive agents; b -- unprotected.

Fig 5. Reinforcing rod following exposure of sample to a sulfurous anhydride medium for 6 months a -- protected with anti-corrosive agents; b -- unprotected.

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